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SOVIET AUTOMATIC PROCESS CONTROL

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/This article describes the development of Soviet automatic process control during the post-war years in the following branches of industry: Electric Power Stations, Metallurgy, Railroad Transport, Machine-Building Plants, the Food Industry, the Chemical Industry, the Coal Industry, the Petroleum Industry, and Light Industry. Future requirements in the field of automatic process control are discussed, and recommendations are made concerning the functions of the Institute of Automatics and Telemechanics, Academy of Sciences USSR7

Introduction

In the Soviet Union, the development of automatic process control has been most marked in electric power stations, ferrous metallurgy, the oil-refining industry, railway transport, the food industry, and some branches of the machine-building industry.

Automatic process control, which was studied in the prewar period, has been developed extensively since the war, and in the last 2 years has come into use in many other branches of industry. However, insufficient attention has been paid to the development and adoption of automatic process control by such important branches as the chemical, coal, mining, and oil-producing industries, light industry and others, which have not introduced automatic control to any great extent, despite the technical feasibility of applying it to many working processes. Almost all the industrial ministries today plan work on automatic process control, but some still tend to neglect this problem.

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It is now possible to summarize general progress and outline basic tasks concerning automatic process control for the more important branches of industry and transportation. It is highly important that this be done in view of the poorly organized exchange of experience on automatic process control and the inadequate coordination of scientific research and experimental design in this branch of science and technology. The Institute of Automatics and Telemechanics, Academy of Sciences USSR, and its journal devote insufficient attention to these problems and to the solution of theoretical and engineering economics questions relating to automatic control in the main branches of industry and to complex automatization of the more important enterprises. The institute is not fulfilling its role of direction and coordination.

This article should stimulate the systematic discussion, in Avtomatika i Telemekhanika, of practical as well as theoretical problems of automatic control. Its scope permits only a brief review of work in progress and future tasks connected with automatic process control in the branches of industry under discussion.

Automatic Control in Electric Power Stations

Under the Ministry of Electric Power Stations, the majority of hydroelectric power stations are already automatic, many steam-electric power stations have automatic regulators for combustion processes and boiler water feed, and introduction of automatic repeated reclosing is almost complete for all transmission lines of 35 kv and above. At present, many hydroelectric power stations are not only fully automatic, but are operated from a central dispatching point located dozens or even hundreds of kilometers away. There are no full-time operators employed at such hydroelectric stations, but only a few maintenance employees. At certain fully automatic hydroelectric stations on the Canal imeni Moscow, even information relating to the operating condition and functioning of equipment can be obtained by dialing.

The Soviet system for automatic control of hydroelectric power stations is highly reliable, and its performance factors excel those of the best foreign-made systems. Operating experience of Soviet automatic hydroelectric stations demonstrates the importance of automatic control from the engineering economics standpoint. At 21 hydroelectric stations having 48 machine units, the number of operating personnel decreased by 75% after the change-over from manual to automatic control.

It should be noted, however, that the automatization program pertaining to steam-electric power stations, instituted by the Ministry of Electric Power Stations, has by no means covered all the basic processes. Here, a more rapid adoption of automatic control is desirable for other parts of the steam section (coke-pulverizing, deaerating, throttle-humidifying, stoking, and other units) as well as for piping systems, in order to achieve complete automatic control of boiler shops and, subsequently, of entire stations. The planning and partial installation of complete automatic control for the boiler shops of a number of large electric power stations, begun last year by the ministry, is proceeding very slowly. It should be kept in mind that the development of complex automatic control of steam-electric power stations is one of the most important aspects of the ministry's work in this field.

Another important task is the promotion of work on the automatization and telemechanization of electrical substations and of the dispatcher control of power systems. These measures should result in more reliable power supply to cities and industrial enterprises.

Automatic Control in Metallurgy

Automatic process control in ferrous metallurgy is proceeding in two basic directions: automatic control of thermal processes in blast furnaces, open-hearth furnaces, metal-rolling units, etc.; and automatic control of electric drives for rolling mills, hoisting equipment, reversing devices, etc.

The best results have been attained in the automatic control of blast and open-hearth furnaces. Automatic regulation of hot blast temperature, which is employed with blast furnaces, results in a 2-3% saving of fuel and ensures smooth operation of the furnace. At present, the pressure in the working space of the furnace, the fuel-air ratio, and valve reversal are automatically controlled in open-hearth furnaces. In addition to reduced fuel expenditure and to economy in refractory materials, automatic control in open-hearth furnaces results in a 7-9% increase in output. This year, four fifths of all cast iron and steel is being produced by furnaces with the above automatic improvements.

With regard to blast and open-hearth furnaces, automatic control should be introduced in a number of other important processes and units in order to permit complete automatic control of furnaces, particularly those operating on oxygen-enriched blast. In the case of blast furnaces, these should include skip hoisting, coke feed, humidification, and interlocking operation of all units; in the case of open-hearth furnaces, regulation of the distribution of combustion products between gas and air regenerators, fuel feed according to the temperature of the crown of the furnace or the regenerators, regulation of the liquid fuel-air ratio, etc.

In rolling mill enterprises of ferrous and nonferrous metallurgy, wider use must be made of automatic control of furnaces and heating units. This should result in fuel savings of up to 10%. It is also necessary to develop the complete automatic control of rolling mills, which should result in an increase of up to 15% in the rolled stock output. Automatic control should also be adopted in the converter production of steel, as well as in electric steel smelting and ferrous-alloy production.

It is imperative to overcome the lag in development and introduction of automatic control in the refractory, coke by-products, mining, and metal products industries and in the dressing of ferrous and nonferrous metal ores. Special stress should be placed on more intense development of automatic control in nonferrous metallurgy. There, it is necessary to automatize reverberatory, induction, shaft, and retort furnaces, as well as the regulation and control of basic processes and units in the production of the more important nonferrous and rare metals. A vast amount of work in scientific research and experimental design must be carried out in order to solve these problems. In addition to organizations of the ministry itself, the Academy of Sciences USSR, and particularly its Institute of Automatics and Telemechanics, can and should participate in this work.

Automatic Control in Railway Transport

During the last 2 years, there has been a substantial increase in the use of automatic control in railway transport, with the purpose of increasing transportation safety and raising performance. One example of automatic control in railway transport is the development by Engineer Tantzyura, Stalin Prize winner, of a resonant-inductive automatic point stop. This is a device for the automatic actuation of locomotive brakes in case an engineer fails to halt the train when approaching a stop signal. Performance data of this device show it to be highly superior to automatic stops in foreign systems. Track sections equipped with these automatic point stops did not report a single instance of equipment failure. In another case, a group of workers of the Scientific-Research Institute of Railroad Transportation perfected a continuously operating automatic stop system with signaling in the locomotive cab. Positive performance data of this system permits its widespread adoption by railroads.

Besides the use of automatic stops, railway transport should continue to press for wide introduction of automatic block signaling (particularly code type), dispatcher centralization (which increases traffic capacity of track sections 20%), electrical centralization of the switch and signal controls (which increases traffic capacity of stations 30% and reduces the number of switchmen), and the route centralization of switches and signals (which results in a tenfold speedup of switching operations, and reduces the number of service personnel). Bryleyev and Fonarev were awarded the Stalin Prize in 1950 for the development of the route centralization of signals and switches. Railroad switchyards must be completely equipped with automatic centrally controlled switches, which speed the work on trains at depots by 15-20% and cut in half the number of car collisions outside the yards.

In order to check the accurate preparation of routes by switchmen, railway transport employs the route-checking device (MKU) designed by Stalin Prize winner Natalevich; a start has also been made in utilizing devices designed by Grigorov. In a short time, about 3,000 stations have been equipped with MKU, and further work is proceeding rapidly. During the next 2 or 3 years, all intermediate stations should have MKU equipment.

Radio communication is employed in the yard area through radio units at the dispatching office and on the switch engines. Radio eliminates time wasted by switch engines in waiting for further work assignments, increases their output by 30-35% and saves at least 10% of the usual time consumed in making up and breaking up trains. The equipment of all large railroad stations with facilities for intrastation radio communications must be completed in the near future. Of even greater engineering economics importance is the adoption of train-station radio communications, which permit the dispatcher to contact the engineers of locomotives at any time. Work on experimental sections thus equipped has been successful. It is therefore time for widespread adoption of train-station radio communications by the more important railroads, particularly on lines with a heavy traffic load and lines subject to snowdrifts.

Further automatization and remote control of traction substations on electrified railroads and subways, and automatization of pumping stations, should also be undertaken.

With reference to railroad cars and locomotives, all rolling stock should be equipped with automatic couplers and brakes, and locomotives should be equipped with automatic speedometers. It is necessary to develop and test models of the automatic railroad car decelerator (the operation of which depends on the weight of the car and its speed), automatic brake shoes, and equipment for intratrain radio communications.

Automatic Control in Machine-Building Plants

Automatic process control in machine-building plants is of very great importance, since it permits a substantial increase in equipment productivity, space economy, and reduction in the number of workers and maintenance personnel. In machine building, automatic control predominates at those shops engaged in the mechanical treatment of machine parts. Along with a considerable growth in the number of automatic, semiautomatic, combination, and special-purpose machine tools, it should be noted that many highly efficient automatic production lines are now operating (or will be operating by 1950). These are used for machining automobile cylinder blocks and transmission gear boxes, tractor cylinder heads, sections and inserts for harvesting machine cutters, rotor shafts, and housings and bases for electric motors.

According to data of the Ministry of the Automobile and Tractor Industry, use of automatic production lines reduces the number of workers eight to ten times, cuts working space by 25-40%, reduces the production cycle two or three times, and results in a several-fold decrease in the cost of manufacture. The number of such lines must be considerably increased in the next few years. In the automobile and tractor industry, automatic lines should be equipped for complete mechanical treatment, and, in some instances, heat treatment, of a number of mass-produced parts such as shafts, connecting rods, valves, etc.

A substantial increase in the number of automatic production lines is necessary at plants building farm machines (parts of farm machines and engines), and transport machines (parts of the S-80 tractor motor, caterpillar components such as links, pins, bushings) and at plants of the Ministry of Machine and Instrument Building (parts for sewing, knitting, and weaving machines, compressors, pumps, valves, slide plates) and of other machine-building ministries.

However, introduction of automatic production lines is not the last step in automatic process control at machine-building plants. Entirely automatic shops and plants are now feasible, and, in the Ministry of the Automobile and Tractor Industry, organization of automatic shops with a closed production cycle is therefore practicable. Such shops would produce engine parts, rear axles, springs, wheels, spark plugs, sprocket assemblies for bicycles, conical, spiral, and needle bearings, roller friction bearings, etc.

Plans should also be drawn for the construction of automatic plants, primarily for the manufacture of gears, rollers for bearings, bearings, and automobile frames. The planning, design, and experimental work, as well as the construction of such automatic lines, shops, and plants, should be carried out by the Ministry of Machine-Tool Building, which already has some experience in these matters. This ministry constructed a number of lines and built an automatic plant for the manufacture of automobile pistons. Projects in the planning and construction of automatic shops and lines can also be undertaken by the ministries of the Automobile and Tractor Industry, Machine and Instrument Building, the Electrical Industry, and the Communications Equipment Industry.

In the case of the Ministry of the Electrical Industry, this would involve lines for the casting of bases and housings for electric motors, for machining parts of different equipment, and for producing units used in winding operations and units for manufacturing conductors with continuously-applied rubber and paper insulation. For the Ministry of the Communications Equipment Industry, it might involve an electric light bulb plant, lines for electrocarbon products, and units for producing storage battery plates and cells.

At machine-building plants, the introduction of high-efficiency machine tools such as automatic and semiautomatic units (particularly of the assembly type) should be continued, and automatic production lines should also be organized for the assembly of such parts as bearings and automobile storage batteries.

In machine-building plants, the extent of automatic control of foundry processes should also be expanded. The following measures should be taken here: introduction of automatic control of the cupola furnace process and of the processes of preparing, sizing, and hauling foundry loam; organization of lines for mass production of mold frames and for moldless casting, lines for casting and hammering out mold frames, and lines and automatic units for trimming and cleaning castings; provision of automatic units for manufacturing and hammering out cores, and for hammering out mold frames on conveyers.

Extensive problems of automatic control must be solved in the field of press-forging production. The most important of these are: automatic control of the preheating and feed of ingots for horizontal forging machines; automatic control of feed to the drop hammers; introduction of automatic devices for feeding and removing ingots to and from heavy hammers and horizontal forging machines; adoption of automatic lines for the mass stamping of parts by mechanical forging and hydraulic stamping presses; automatic control of anchor chain production; automatic control for forging, stamping, and annealing mass-produced parts; automatic control of thermal processes in preheating furnaces, etc.

Of great importance are the special automatic machines for the sizing and sorting of mass-produced parts, now widely used in the production of automobiles, tractors, farm machines, railroad cars, electric motors, bicycles, electric bulbs, plates, needles, fasteners, tools, fittings, etc. Other problems encountered in automatic process control at machine-building plants are: automatic control of thermal processes in furnaces for heat treatment; adoption of automatic production lines and automatic presses for cold pressing and stamping; automatic control of electroplating and of plastic, ceramic, cable, abrasive, and electric-bulb production, etc.

In addition to research and planning on the automatic devices, lines, shops, and plants mentioned above, it is necessary to develop methods for determining the most efficient level and engineering-economics effectiveness of automatic control in the various machine-building enterprises. It is possible that the Institute of Automatics and Telemechanics, Academy of Sciences USSR, should participate in this work.

Automatic Control in the Food Industry

Concurrently with the completion of mechanization of manual operations (which was begun before the war), food enterprises are successfully adopting automatic process control. Large numbers of various automatic and semiautomatic units are used for unpacking, sizing, and packaging foodstuffs such as bakery products, sugar, tea, ice cream, meat dumplings, and margarine, thus permitting the release of a substantial number of workers from low-productive manual operations. The automatic regulation of thermal processes is also being adopted; this results in high quality production in the bread-baking, canning, alcohol, and sugar industries. The introduction of automatically controlled bread-baking processes in only half of the bread-baking plants would result in an annual saving of several thousand tons of flour (because of reduced baking waste). In the liqueur and vodka, brewing, and dairy industries, automatic production lines for bottle washing, pouring, and bottle capping have been introduced.

There has been an increase in the number of automatic lines used in the production of tin cans for the food, meat and dairy, and fish industries. The extensive introduction of automatic worm presses by the fat-processing industry has increased the production of vegetable oil by many thousands of tons. However, the scope and tempo of adoption of automatic control in a number of food-processing enterprises are inadequate. It is necessary to extend the use of automatic instruments for signaling, measuring, checking, and regulating all the basic parameters of technological processes, particularly for automatic control of food-product sorting and of air conditioning installations, etc.

Automatic Control in the Chemical Industry

The chemical industry, with manufacturing processes frequently harmful and dangerous to humans, needs more rapid and widespread adoption of automatic control. Although automatic control was introduced in the chemical industry before the war, the desired results have not been attained in this field.

The most intensive development of automatic control took place in the nitrogen industry and later in the synthetic rubber industry, two industries distinguished for their up-to-date technology and complex equipment. Development of automatic control proceeded principally along the line of adoption of automatic and centralized control of the physical parameters of technological processes: pressure, temperature, discharge of liquids and gases, level, etc.

Recently, automatic control has spread to other branches of the chemical industry. Automatic control of the carbonation process in soda production and of synthetic hydrochloric acid production has been successfully accomplished. Automatic controls are being adopted by the aniline-dye industry, by the heavy organic industry, and in the production of inorganic acids, fertilizers, and alkalis.

However, automatization is still proceeding primarily in the direction of automatic control. As a rule, automatic regulation has not been adequately developed. Up to now, no solution is available to the problems of complex automatization of inorganic acid production, in particular sulfuric and nitric acids, ammonia, and calcined and electrolytic soda. Automatic control should be extended primarily to these enterprises, as well as to those producing synthetic rubber, plastics, and rubberoid products, in order to create suitable conditions for their complete automatization in the future. Automatization of inorganic acid and alkali plants will increase their productivity by about 8-10%, with a 4-5% reduction in the expenditure of raw materials and a 3-4% reduction in fuel consumption.

The development of basic problems and methods of automatic control in various enterprises should be undertaken by the Academy of Sciences USSR, and by the scientific-research and planning institutes of the Ministry of the Chemical Industry. First priority should be given to development of methods and systems for complete automatic control of the production of synthetic rubber, ammonia, nitric and sulfuric acids, and basic products of the organic industry. This particularly applies to the development of systems of complex automatic control for plants presently engaged in producing the above products, and also for plants producing soda, chlorine, and principal dyestuff intermediates, but it also applies to the development of special equipment.

Automatic Control in the Coal Industry

Partial automatic control is now being adopted by the coal mines, particularly remote control of coal digging machines and coal hauling devices in the mine and on the surface, (central block signaling systems) (STsB) for electrically operated haulers, and automatic control of water drainage installations. At the same time, in both the coal- and ore-mining industries, it is quite possible to achieve almost complete automatic control of coal and ore delivery at the mine's surface, of the dressing and loading of coal and ore, and of the removal of tailings to the rock dump. However, not one mine is in fact equipped with such complex automatic surface structures.

Furthermore, automatic control should be provided for the main machines, such as cutting machines, conveyers, compressors, and ventilators. Extensive dispatcher control of technological processes and mechanisms should be introduced at all large mines along with automatic control and signaling. The current extensive mechanization of work in the coal industry substantially

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increases the number of machines and mechanisms whose operation requires new workers. Therefore, mechanization frequently does not reduce the number of workers in the coal industry but instead results in the nonproductive employment of many workers engaged in servicing these machines and mechanisms. Automatic control permits the complete release of maintenance workers and thus considerably increases the effectiveness of mechanization.

The Ministry of the Coal Industry devotes little attention to the extensive introduction of automatic control in the coal mines, particularly to the development and utilization of complex automatic control at adequately mechanized mines. Nor does the Academy of Sciences USSR devote enough attention to the solution of theoretical and technical problems concerning automatic control of the entire coal-production cycle.

Automatic Control in the Petroleum Industry

In the petroleum industry, automatic control has been used extensively only in oil-refining operations. Automatic control of exploration, drilling, recovery, and storage processes for oil and gas is almost nonexistent. Automatic control of these processes would increase production output, improve quality, reduce the consumption of raw materials, fuel, and electric power, and prolong the life of equipment. In this industry, the following measures are required: automatic centralized control of well operations, of level of oil, and of oil products in storage tanks; automatic control and telemechanization of oil and gas pipelines, etc.

The Ministry of the Petroleum Industry has paid little attention to automatic process control problems in the oil-producing industry; as a result, it has no engineering solutions prepared for the automatic control of a number of processes. The Academy of Sciences USSR should be drawn into the development of automatic control of the processes used in the oil-producing and gas industries.

Automatic Control in Light Industry

Light industry, with its manual (predominantly female) labor and its enterprises with thermal and chemical production processes, has special need for automatic process control. Despite the diversity of its branches, only isolated use has been made of automatic process control: in automatic looms, automatic regulators of solution concentration in the textile field, automatic machines for making knitted goods, and automatic and semiautomatic machines for shoe manufacture. Complex automatic control is required for machines used in the production of artificial silk and of circular spinning frames and other equipment. It also should be used in leather tanning processes, hot vulcanization of shoes, and in chemicotechnological and thermal processes in the finishing enterprises.

Conclusions

How can the lack of uniformity in the adoption of automatic process control in various fields of industry be explained? Certainly not by the fact that the task is considerably easier in the leading branches of industry. Administrative personnel and engineers of the Ministries of the Metallurgical Industry, Transportation, Electric Power Stations, the Automobile and Tractor Industry, and the Food Industry have long appreciated the great engineering-economics importance of automatic control and have worked for its adoption despite the difficulties. They established their own scientific-research, planning and design, installation and testing organizations for automatic control and themselves undertook production of the necessary equipment. All other ministries and their associated organizations and enterprises should follow this example or risk being left behind in the adoption of advanced techniques.

It should be noted, however, that in solving the key problem in the extensive adoption of automatic process control, i.e., the problem of quality and availability of the necessary automatic control equipment, the final responsibility rests with the all-union instrument-building enterprises.

The ever-increasing use of very high pressures, temperatures, speeds, and voltages requires the design of equipment with improved accuracy and speed of regulation, inertia, continuous process recording, etc.

At present, the all-union industry is capable of intensive instrument production and has a large number of experimental design bureaus and plants capable of solving highly complex engineering and production problems. Bureaus and plants of the Ministries of the Aviation Industry, Machine-Tool Building, the Electrical Industry, Machine and Instrument Building, and Transportation-Machine Building have produced a large quantity of the newest instruments for various purposes during the postwar period. At present, about 500 types of automatic control equipment are being produced. These include, for example, such high-quality instruments as automatic bridges and potentiometers, ratiometers, automatic units for checking and sorting machine parts according to size, and automatic electric drives for the metallurgical, mining, and heavy machine-tool industries, and for power plants, printing, etc.

Many specialized instruments have been designed by individual ministries to meet their particular needs: by the Ministry of the Petroleum Industry, volumetric meters, electronic scales, indicators for registering oil-well parameters, etc.; by the Ministry of the Metallurgical Industry, inductive tensiometers, automatic gas analyzers, pulp-density regulators, photorelays, etc.; by the Ministry of Electric Power Stations, automatic regulators of thermal processes; by the Ministry of the Food Industry, hygrometers, turbidity meters, installations for control and automatic operation of bread-baking ovens, etc. However, the total number of automatic instruments being produced is inadequate for the ever-growing requirements of the national economy.

The present dispersion of instrument building among the many ministries requires close scientific and technical coordination in developing and producing new types of instruments. However, the Technical Council on Instrument Building of the Ministry of Machine and Instrument Building, which was created in 1946 by government decree, is practically inactive. Meanwhile, poor organization for technical problems leads to inefficient utilization of specialists and production capacities, because of duplication of effort. Thus, such commonly used instruments as potentiometers, shielded electrical measuring instruments, time-delay relays, and certain others are produced simultaneously by several ministries. On the other hand, certain instruments required in automatic control and regulation, automatic electric drive and follower systems, electronics, telemechanics, and loading, clamping, and hauling units for automatic control in machine building are being developed very slowly. The production of instruments for automatic control and regulation, automatic starting and regulating equipment, and control equipment for machine building must be increased substantially. In particular, it is imperative that the production of certain scarce types of instruments be expanded: automatic electronic potentiometers, direct-acting regulators, reference elements, and remote-control instruments. In instrument and equipment building, it is also necessary to accelerate the adoption of new developments, such as magnetic amplifiers, contactless systems, etc.

The existing practice of developing new types of automatic instruments for narrowly specialized purposes must be changed in favor of designing universal instruments on the block unit principle. Some ministries (Aviation Industry, Metallurgical Industry, etc.) already have adopted this practice and designed a series of universal electronic bridges, potentiometers, and other instruments. A number of models of universal instruments which can be utilized in most regulated and controlled processes have been developed by the Institute of Automatics and Telemechanics, Academy of Sciences USSR.

At the institute's initiative, measures are being worked out for extensive and planned development of scientific-research and experimental work on equipment constructed according to the block unit principle, and for gradual conversion to the production of universal instruments for automatic control and regulation.

Such a system aims at the creation of a series of standard types of equipment to provide control and regulation of all the physicochemical production parameters met in practice. It also envisages the development of a few types of sensitive elements and of a limited number of converters, amplifiers, shielded instruments, and control and reference devices. The system would be based on electrical equipment since this is the most flexible, but a pneumatic system is provided as an alternative for use in production processes where the danger of explosion exists. In addition to complex equipment for indirect-acting regulation, the development of simple equipment for direct regulation is also planned.

Adoption of the proposed system should ease considerably the task of instrument building for the following reasons: sharp reduction in the number of types of instruments produced and a consequent reduction of production time (2.5-3 times according to preliminary estimates); improvement of engineering-economics indexes (reduction in the number of workers, amount of equipment, and space); and reduction in the initial capital investments required for instrument-building plants.

Thus, in addition to the engineering solution of the problem, which will provide equipment for automatic process control in most fields, the block-unit system of instruments provides the most economical production base. The block-unit principle can also be applied to accelerate the use of automatic process control in machine building. Although the mechanical units of machines differ according to type of equipment, the hydraulic, pneumatic, electrical and electronic units can be standardized to a considerable degree and centrally produced. These units are automatic or semiautomatic devices for loading, hauling, clamping, turning, sizing, controlling, regulating, and interlocking. Block units not only permit rapid machine production, but are readily adaptable to machine modification.

If block units and instruments were centrally produced, any ordinary machine-building plant could produce the automatic and semiautomatic types of equipment corresponding to their particular production requirements. In these conditions, machine-tool-building plants could themselves greatly increase the variety and number of automatic and semiautomatic units and automatic lines they produce.

Considering the ever-growing requirements for quality and quantity of automatic control instruments and equipment, the Ministries of Machine and Instrument Building, the Electrical Industry, the Communications Equipment Industry, and Machine-Tool Building (and also their enterprises) must expand the development and production of all necessary items.

Of great importance in the extensive use of automatic process control is the production of automatically controlled machines, machine tools, and mechanisms and their supply to the consumer complete with all the necessary auxiliary automatic devices. The first steps in this direction have been already taken. Rolling and blooming mills, power equipment, turboblowers, and electric steel-smelting furnaces are produced, complete with all auxiliary automatic devices. Coal-cutting machines, coal combines and excavators, and coal-loading machines are at present only produced with remote control. The new MV-60 coal-cutting machine went into production in 1948. This has a number of outstanding advantages compared with previous models but its main defect is the lack of automatic control of cutting speed. The operator of the coal-cutting machine has to establish the cutting speed by ear, depending on the toughness of the coal, and the machine slips if cutting speed exceeds permissible speed. As a result, productivity of the machine is reduced, and with it, the over-all take of coal from the stope.

The Ministry of Machine-Tool Building produces grinding machines without attachments for automatic checking of parts during the grinding process. The Ministry of Machine and Instrument Building produces pulverizers for foundry shops without automatic selection and feed of the mold components, and without timing regulators and automatic unloading of finished mixtures. The molding machines now produced are not equipped with sizing devices or automatic regulation of the mold density. Despite the government decree, the Ministries of the Electrical Industry, the Aviation Industry, and Machine and Instrument Building have not yet organized production of electric furnaces and baths with automatic temperature regulation for forging and heat-treating shops.

It is the duty of the Ministries of Heavy Machine Building, the Electrical Industry, Machine and Instrument Building, the Coal Industry, the Aviation Industry, and others, to furnish all the main equipment they produce with the necessary automatic control devices as soon as possible. In 1950, it is particularly important to supply equipment complete with devices for automatic control and regulation of temperature, discharge, level, pressure, and concentration of liquids and gases, to soda-making enterprises, enterprises producing sulfuric acid by the contact process, and enterprises producing nitric acid, hydrochloric acid, and other chemical products.

General conclusions on Soviet progress and future requirements in the field of automatic process control can be summarized as follows:

1. In addition to the ministries already mentioned, automatic process control is also being adopted by enterprises of the Ministries of Communications, the Paper and Cellulose Industry, the Construction Materials Industry, Cinematography, and the Printing Industry. Ministries backward in this respect must catch up quickly.

2. There is a clear tendency in most branches of industry toward complex automatic control of enterprises (shops, plants, mines, electric power stations). This is understandable since automatic control of isolated units and processes does not produce adequate engineering economic results. For example, the establishment of automatic production lines at enterprises affects their entire organization because effective use of these automatic lines requires a corresponding productivity increase in remaining operations where lines are not used, i.e., it calls for further automatic process control. Complex automatic control requires correct determination of the volume and extent of automatic control in an enterprise from the engineering-economics standpoint. The Institute of Automatics and Telemechanics must take an active part in the application of this work to the leading branches of industry.

3. In the very near future, some industries, e.g., the food industry, light industry, machine building, trading systems, etc., should adopt automatic control in the form of special automatic and semiautomatic units, and should also introduce automatic main equipment, either supplied complete with automatic control devices or at least constructed for easy adaptation to automatic control.

4. More extensive use of telemechanics is necessary since, in conjunction with automatic control, it provides the most modern method of production regulation. This is particularly true in the case of the power, petroleum, gas, and metallurgical industries, and railway transport.

5. More extensive development and production of all the necessary automatic and telemechanical instruments and equipment is required, based on the design of universal instruments using the block unit principle.

6. Exchange of operating experience on automatic process control should be improved and all the necessary scientific research and experimental design work on automatic process control should be implemented. The Institute of Automatics and Telemechanics, Academy of Sciences USSR, should direct and coordinate this work on the lines indicated above.

7. An accepted principle must be established quickly, whereby all new electric power plants, mines, oil and gas pipelines, and other enterprises are planned and constructed to incorporate the latest designs in automatic control. A more rapid conversion of existing facilities to automatic operation is also necessary.

Two other important and interrelated questions which affect the success of change-over to automatic process control are training automatic-control specialists, and organizing the work on planning, installation, adjustment, and operation of automatic units. These questions are outside the scope of this article and are likely to be the subject of a special study.

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